Pergamon

World Development, Vol. 25, No. 2, pp. 255–266, 1997

0305–750X/97 $17.00 + 0.00

S0305-750X(96)00100-3

When Households Run Out of Fuel: Responses of Rural Households to Decreasing Fuelwood Availability, Ntcheu District, Malawi

INGE D. BROUWER
Wageningen Agricultural University, Wageningen, The Netherlands

JAN C. HOORWEG
African Studies Centre, Leiden, The Netherlands

and

MARTI J. VAN LIERE*
Wageningen Agricultural University, Wageningen, The Netherlands

Summary. — This paper examines strategies used by rural households in Central Malawi to cope with a decreasing fuelwood availability. With increasing distance to woodlands, households initially collected further away, spending more time on collection. But when distance to woodlands increased, households returned to nearby places using less time for collection and switching to lower quality wood. Results indicate that distance to collection place and collection time are not reliable indicators of fuelwood shortages as so often postulated in the literature. Households within the same village differed in collection strategies particularly as regards collection distance and collection frequency. Households that tended to collect further away and more frequently were large in size with more female adults. These households also collected more wood, even per capita, compared to smaller households, suggesting that smaller households economized on fuelwood use. This paper supports the idea that level of fuelwood used is not only determined by fuelwood availability, but the more by labor availability. © 1997 Elsevier Science Ltd. All rights reserved

Key words — fuelwood shortage, household fuel use, fuelwood collection, labor, seasonality, Malawi

1. INTRODUCTION

In most African countries fuelwood and charcoal are the main sources of household energy. Rural households depend on fuelwood in particular. In Malawi about 60% of the total fuelwood demand is consumed by rural households and this wood is mainly used for food preparation (French, 1986; Armitage and Schramm, 1989). In Malawi, however, woodlands from which most wood is obtained are becoming depleted as a result of clearance of land for agriculture, excessive livestock grazing and the demands for wood by the tobacco industry. Furthermore, the high price of gas and oil and the uncertain supply through neighboring countries, retards the transition from fuelwood to liquid fuel (Malawi Government, 1987a). The depletion of the woodlands combined with the persistent dependency on fuelwood will eventually pose a serious problem for household energy provision (French, 1986). Fuelwood supply is already considered critical in densely populated areas of the Central and Southern Regions of Malawi. In addition, the influx

*This study was supported by the Agricultural University, Wageningen, and the African Studies Centre, Leiden, The Netherlands. We acknowledge gratefully the assistance of the Centre for Social Research, University of Malawi. Our sincere thanks go to Mandaaliza Kamwendo, Mike Jeremiah, Paul Damiano, Joe Njenekera and Patrick Kumpukwe, without whom we would not have been able to carry out the study. We thank Prof. J. G. A. J. Hautvast and Dr A. P. den Hartog, for their valuable comments and ideas on earlier drafts of this paper. Final revision accepted: July 8, 1996.

of refugees from Mozambique constitutes a further pressure on existing woodlands in the border regions (ETC, 1987a).

Rural households develop different strategies to cope with decreasing fuelwood availability. The concept of household coping strategies has, until now, mainly been used in research on food security and seasonal food shortages. The term "strategy" is used to describe what households do when faced with a threat and refers to overall planned actions. The term "response" is used for each of the individual actions undertaken within a strategy (Corbett, 1988). Several responses may be undertaken by different household members at the same time or sequentially, as part of the same overall strategy. Longhurst (1986) and Foeken and Hoorweg (1988) distinguish preventive responses and responses to meet actual stress. Contrary to seasonal food shortages that have a transitory character, fuelwood shortages have a more chronic character as the situation is usually worsening with time. Most responses aim to meet actual stress, only some aim at prevention of worse effects in the future (for example, the planting of trees).

An earlier review paper (Brouwer *et al.*, 1989) discussed existing literature and information on behavioral responses of rural populations to a decreasing fuelwood availability (Table 1). These responses include collection at longer distances, spending more time on collection, enlisting younger and older household members and adjusting the weight of the bundle collected. Adaptations also occur in type of fuel used, by a switch to fuel of an inferior quality or to wood from fruit trees and by purchasing fuelwood. People also try to cut back on the amount of fuelwood used. It is often assumed that these various responses in a population can be used as indicators of fuelwood scarcity and that these responses will occur more frequently in areas with less fuelwood availability (ETC, 1987b). Most of the literature, however, is based on limited observations rather than on substantive research. Moreover, the actual responses depend on individual decisions at household level and are dependent on the available labor, household entitlements, access to woodlands as well as cultural practices. Consequently, there is urgent need for detailed data on different populations (Cline-Cole, Main and Nichol, 1990).

This paper presents empirical evidence on the responses of rural households to a decreasing fuelwood availability in Malawi. The study described is part of a research project that looked into the consequences of a decreasing fuelwood availability for the nutritional conditions of rural households in Ntcheu District. Following a general description of fuel supply and use patterns, these responses are examined in two ways. First, fuel supply and use patterns in four villages located at different distances from woodlands are compared and seasonal variations are studied. Second, households with different fuel collection strategies are compared concerning fuel supply and use patterns, and socioeconomic characteristics.

Table 1. *Responses of rural households to fuelwood scarcity*

Responses	Source
1. *Fuel collection*	
— increase in distance	(Howes, 1985; ETC, 1987b; Groen, 1988/89)
— increase in collection time	(Hoskins, 1980; Howes, 1985; Schenk-Sandbergen, 1985; ETC, 1987b; Groen, 1988/89)
— change in who collects (more children, older women, men)	(Fleuret and Fleuret, 1978; FAO 1983; Eckholm *et al.*, 1984; Howes, 1985; ETC, 1987b; Groen, 1988/89; Ngugi and Bradley, 1986)
— increase in frequency of collection	
— change in weight of bundle collected	(Ki-Zerbo, 1981; Cecelski, 1987)
2. *Type of fuel used*	
— use of less preferred types of fuel (twigs, crop residues)	(Hoskins, 1980; Ki-Zerbo, 1981; Malawi Government, 1981; FAO, 1983; Hosier, 1984; Howes 1985; Ngugi and Bradley, 1986; ETC, 1987b; Bradley, 1988, Groen, 1988/89; Dankelman and Davidson, 1989)
— increase in purchase of fuelwood	(Malawi Government, 1981; Eckholm *et al.*, 1984; Howes, 1985; Longhurst, 1985; ETC, 1987b; Groen, 1988/89)
— increased use of fruit trees	(Malawi Government, 1981; Shanahan, 1986)
3. *Fuel use*	
— reduction in energy end-uses	(Hoskins, 1980; Cecelski, 1985; Ardayfio, 1986; ETC, 1987b; Groen, 1988/89)
— decrease in stock building	(Ngugi and Bradley, 1986; Bradley, 1991)
— decrease in sales and exchange of fuelwood	

Source: Based on Brouwer *et al.* (1989).

2. STUDY POPULATION AND DESIGN

(a) *Ntcheu District*

Research was carried out in Ntcheu District in the Central Region of Malawi near the Mozambiquan border in the West. Ntcheu is one of the districts with apparent fuelwood supply problems, especially in the densely populated areas of the district (ETC, 1987a). The district is characterized by a relatively high population density (105 inhabitants per squared kilometer) with an annual population growth of 4.6% (Malawi Government, 1987b). The vegetation consists largely of woodland savanna with an annual precipitation of 900 mm concentrated in the rainy season (Malawi Government, 1989). There are three seasons; a cool dry season from mid-April to mid-August (postharvest season), a hot period during which relative little humidity builds up between August and mid-November (dry season), and a period of tropical rains between November and April (rainy season). Daily temperatures vary from 18°C in July to 36°C in October. The main economic activity is subsistence farming. The most widely grown food crop is maize; other crops are finger millet, pulses, groundnuts and vegetables. Primary sources of fuelwood are natural forests and savanna woodlands.

(b) *Study population and design*

The research locations are four villages situated along the (sandy) Ntcheu-Kasinje road. Selection was based on distance to woodlands (see Figure 1), being < 1.5 km (Muuso), 2.5–3 km (Kachinjika), 4–6 km (Chimpuza), and > 6 km (Magola).

Following a census of the four villages, 200 households were randomly selected (50 in each village) meeting criteria concerning permanent residence, origin and size of household. A general questionnaire was administered to each household in October–November 1990 (dry season). Questions concerned demographic characteristics (head of household, household composition), farm characteristics (size of land holding, cash crop cultivation), off-farm employment, fuel uses (type of fuel, end-uses, exchange, stock), fuel purchase and collection (place, distance, frequency, time, amount, persons responsible).[1] To determine the weight of wood collected, women were asked to lay out wood equivalent to the amount collected last time and this amount was weighed by the research team.

In order to capture within-year variations in fuel supply and use patterns, further data were also collected for a random subsample of 120 households during two more seasons, namely the rainy season (January–March 1991) and the postharvest dry season (June–August, 1991). For 113 households data sets were obtained for all three seasons.

(c) *Data analysis*

To describe fuel supply and use patterns, data concerning fuelwood used for domestic purposes were first analyzed for the total research population of 200 households. Averages and distributions were calculated for type of fuel used, fuel supply (collection or purchase), exchange and presence of stock of fuelwood. The total collection time and total quantity of fuelwood collected were calculated with the help of information on time spent per trip, frequency of collection, number of persons collecting and amount of fuelwood collected per trip.[2]

Next, fuel supply and fuel use were compared between the four villages with particular attention for fuel collection characteristics, types of fuel used, amounts of wood collected, and seasonal variation in fuel collection. The data from one point in time were used as a proxy for time-series data to discuss behavior over time as wood grows scarce.

The analysis then focused on a comparison between four strategy groups, based on a distinction between collection distance (far/near) and collection frequency (high/low). The categorization in strategy groups is further described in section 5. Analysis were carried out with use of statistics for nonparametric data (Siegel and Castellan, 1988). Differences between the four villages as regards fuel supply and fuel use patterns and seasons, and between the four strategy groups as regards socioeconomic characteristics, fuel supply and use variables were tested with help of the Kruskal-Wallis and Chi square tests ($p < 0.05$). If these tests showed significance, multi-comparison was used in order to determine which subgroups differed with the help of the Mann-Whitney or Chi square tests ($p < 0.01$). Differences between seasons were tested with Friedman two-way analysis of variance by ranks and the Cochran Q test ($p < 0.05$). If these tests showed significance, the Wilcoxon signed rank test for matched pairs and McNemar change test ($p < 0.01$) were used to determine which seasons differed. All data were analyzed by means of SYSTAT and SPSS-PC 4.0 software (Wilkinson, 1989; Norusis, 1990, respectively).

3. FUEL SUPPLY AND FUEL USE PATTERNS

(a) *End uses and type of fuel used*

All households used fuelwood for cooking, space heating, and heating bath water. In addition, 46% of the households used fuel for smoking fish or meat and 11% for brewing beer. Only 3% used fuel for brick making, since bricks are usually dried in the sun. There was no curing of tobacco or making of charcoal in the research area.

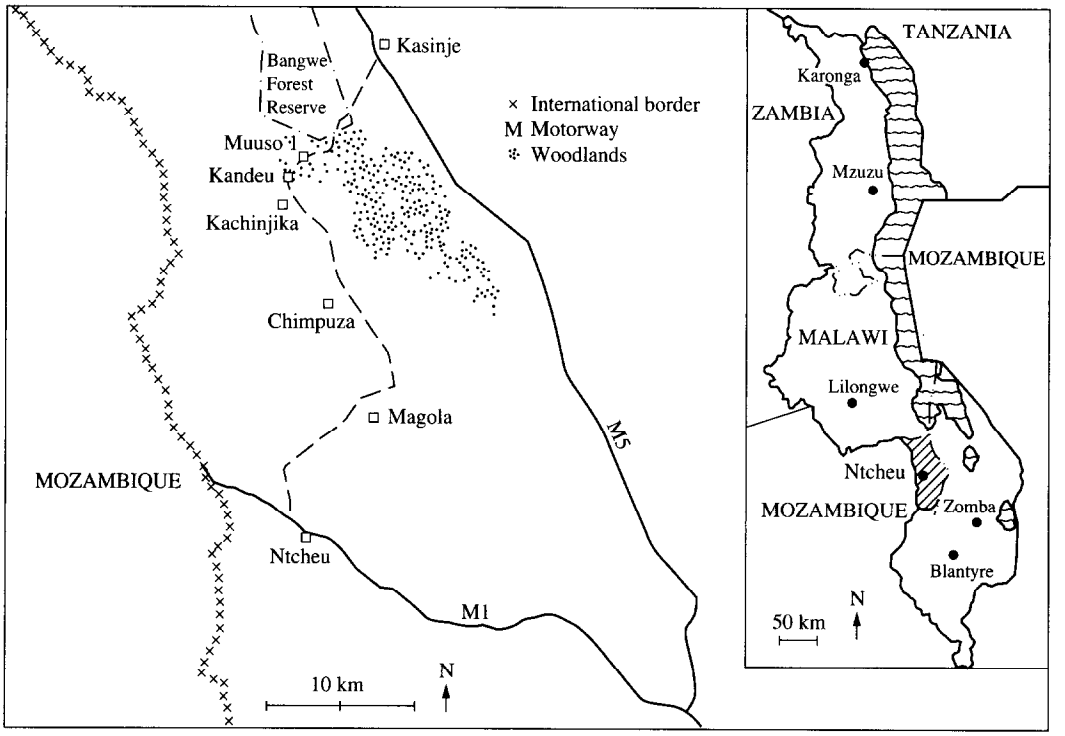

Figure 1. *Map of the research villages, Ntcheu District, with small display of Malawi.*

The dominant type of fuel used was fuelwood, in the form of splitwood, branches and twigs.[3] For food preparation women strongly preferred the first two types of wood and in particular those from the indigenous tsamba tree (*Brachistegia spp.*). Wood from the following trees was also used regularly: mthethe (*Acaciapolycantha*), sederela (*Toona ciliata*), mwanga (*Pericopsis angolensis*), and the blue gum (*Eucalyptus globulus*). Cuttings from mango trees (*Mangifera indica*), which are pruned yearly, were also used although they are not favored by women because of their poor burning quality. Charcoal was seldom used and none of the households burned animal dung. The only nonwood fuel used was paraffin, used for lighting, by 84% of the households. Few households used dry grass for lighting when paraffin was not available.

(b) *Fuel collection versus fuel purchases*

Nearly all households (98%) reported that the wood used for cooking was collected. Households with a money income from activities such as beer brewing and brick making, tended to purchase wood, although the number was rather low (five out of 29). In cases where wood was purchased, mainly splitwood and branches were bought from a salesman coming to the houses. Households buying wood did this on average once a month spending five MK.[4] Paraffin was bought on the local markets or in Ntcheu town. Most households bought paraffin either weekly (27%) or monthly (29%), but the consumption was very limited: an average of only two MK per month was spent on this fuel.

Women were almost exclusively responsible for the collection of fuelwood; 95% of all collectors being female. Sometimes, however, men assisted but this happened only in exceptional situations if, for instance, the woman was not able to collect wood because of illness or old age. The wood collectors were mainly between the age of 16 and 59 years (78% of the collectors). They received some help from young and older household members: 12% of the collectors were younger than 16 years and 10% were 60 years or above.

Wood was mostly collected from natural forest and communal lands (74%), whereas 26% of the households also collected wood from their own farm or from the farm of their neighbors. The wood collected was transported by headload; no other means of transport was used.

(c) *Exchange of wood for food*

Since 1986 the number of Mozambiquan refugees in Malawi had greatly increased. They receive food aid from the United Nations High Commissioner for Refugees (UNHCR) consisting of maize flour, pulses, groundnuts, sugar, salt and cooking oil. A considerable trade of commodities has developed since then between the Mozambiquan and Malawian populations. Fuelwood is one of the commodities exchanged by Malawians for maize flour and sometimes cooking oil from the refugees. The exchange most frequently occurred during the dry season (35% of the households). During the rainy season this kind of exchange occurred less often (14%) although food stocks were low at that time, which probably indicates that heavy farm labor stopped women traveling to the refugee areas. In the postharvest season, when households can rely on their new harvest, only 1% of the households exchanged wood.

(d) *Stock*

Storage of wood has several benefits. The stored wood can be used in times of emergencies such as illness or funerals and in times when labor demands prevent women from collecting fuelwood. Wood is also stored and dried for use during the rainy season when the wood in the woodlands and bushes is often too wet for direct use. A stock was defined as any wood stored near the house, if the amount would last for more than one week. On average, 35% of the households had a stock in the dry season. This percentage increased during the rainy season, when 52% of the households had a stock. During the postharvest season this diminished to 17%. Apparently, during the dry season time is invested to build up stocks for the rainy season. In all seasons, stocks mainly comprised splitwood and branches, but during the rainy season 14% of the households also stored crop residues (such as maize stalks and maize cobs).

4. FUEL COLLECTION IN FOUR VILLAGES LOCATED AT INCREASING DISTANCES FROM WOODLANDS

The area under study has experienced a transition to less fuelwood availability with the threat of future scarcities. Most households reported that they were able to collect enough wood, but 24% already replied the contrary. Aerial photographs of the four research villages showed that with greater distance to woodlands the tree and shrub cover immediately surrounding the villages also decreased.[5] Households from different villages indicated more problems with fuel collection with increasing distance to woodlands. All households in Muuso, situated less than 1.5 km from woodlands, were able to collect enough wood. About 10% of the households in Kachinjika (2.5–3 km from woodlands) and Chimpuza (4–6 km from woodlands) indicated that they were not able to collect enough wood, whereas in Magola (> 6 km from woodlands) this percentage was more than double (24%).

(a) *Fuel collection*

Table 2 shows fuel supply and fuel use characteristics of the four villages in the dry season (October–November 1990). With increasing distance to woodlands (Muuso versus Kachinjika), fuelwood was initially collected at longer distances (1.1 km and 4.0 km respectively) and households spent increasing time on collection (6.0 and 10.0 hr/week). When woodlands had to be reached much further away (Chimpuza and Magola), households returned to other, nearby, places (3.0 km and 1.0 km respectively), reducing collection time (6.0 hr/week). No significant differences were found in frequency of fuelwood collection between the villages.

Data indicate that when households returned to nearby places (Chimpuza and Magola), more switched to twigs which are found in bushes surrounding the village (12 and 37% respectively use twigs in food preparation). The use of cuttings from mango trees was also increased in villages located at greater distance to woodlands. Both twigs and mango cuttings are considered inferior fuelwood that have low burning quality (Brouwer *et al.*, 1996a).

Total amount and per capita amount of wood collected per week declined with increasing distance to woodlands, with the lowest value in the village located at 4–6 km from woodlands (Chimpuza: 33 kg/week and 8.1 kg/cap/week respectively). In the village located at more than 6 km from woodlands, the total amount and per capita wood collected were again higher. This can be explained by the increased use of twigs, as cooking on twigs requires greater amounts of wood (Brouwer *et al.*, 1996a) and, therefore, more wood needs to be collected.

(b) *Seasonal variation*

Fuel collection was also studied during the rainy (January–March 1991) and the postharvest season (June–August 1991), among a subsample of the larger research population. Table 3 shows that during the rainy season the number of households collecting fuelwood was smaller compared to other seasons (except the village nearest to woodlands). In both the rainy and the postharvest season, the percentage of households collecting fuelwood in the village at more

Table 2. *Fuel collection characteristics of households in four villages located at increasing distances from woodlands, Ntcheu District, Malawi* (n = 200)*

	Villages			
Distance to woodlands	Muuso < 1.5 km (n = 51)	Kachinjika 2.5–3 km (n = 49)	Chimpuza 4–6 km (n = 50)	Magola > 6 km (n = 51)
Fuel collection				
— Collection distance (km)	1.1 (1.0–2.0)	4.0† (3.0–4.8)	3.0 (2.0–4.0)	1.0‡ (0.5–2.0)
— Collection frequency (times/week)	2.0 (2.0–3.0)	2.0 (1.5–3.0)	2.0 (1.0–3.0)	3.0 (2.0–4.0)
— Total collection time (hours/week)	6.0 (4.0–6.3)	10.0† (6.0–15.0)	6.0§ (4.0–10.0)	6.0§ (3.0–9.0)
Type of fuel used				
— Households using twigs (%)	6	8	12	37‡
— Households using wood from mango trees (%)	22	78†	62†	77†
Total amount of wood collected				
— Total amount of wood collected (kg/week)	42.6 (33.4–62.0)	44.2 (29.5–59.5)	33.0† (21.0–49.8)	39.7 (26.7–52.0)
— Wood collected per capita (kg/week/capita)	9.2 (6.1–14.0)	9.0 (6.1–11.8)	8.1 (4.9–12.4)	9.9 (6.9–14.8)

*Median (25th–75th percentiles).
†Significantly different from Muuso, $p < 0.01$.
‡Significantly different from Muuso, Kachinjika and Chimpuza, $p < 0.01$.
§Significantly different from Kachinjika, $p < 0.01$.
¶Significantly different from Chimpuza, $p < 0.01$.

than 6 km from woodlands (Magola), was smaller compared to that in the other villages. Households not collecting fuelwood usually used wood from stocks that they have laid on.

No significant differences between the seasons were found as regards distance to collection place, per capita amount of wood collected, total weekly collection time and the use of twigs, with a few exceptions (Table 4).

5. FUEL COLLECTION STRATEGIES

Apart from differences between villages there are also differences in fuelwood collection between households within the same village. The choice by households where to collect, how often to collect and how much time to spend on collection is not only dependent on geographical location and fuelwood availability but also depends on individual decisions at the household level. With greater distance to woodlands some households will collect at larger distance but others may decide to collect nearby, perhaps more frequently. Fuel supply and fuel use showed considerable variation within villages as indicated by the range of scores in Table 2.

Examination of the data revealed that households differed especially in two basic characteristics

Table 3. *Percentage of households that actually collected fuelwood the week prior to the interview in three seasons, Ntcheu District, Malawi*

	Villages			
Distance to woodlands	Muuso < 1.5 km (n = 26)	Kachinjika 2.5–3 km (n = 27)	Chimpuza 4–6 km (n = 31)	Magola > 6 km (n = 29)
Dry season	100	100	100	100
Rainy season	85	70	71	59
Postharvest season	85	89	94	76

Table 4. *Seasonal variation in fuel collection among households in four villages differing in distance to woodlands Ntcheu District, Malawi* (n = *113*)*

	Muuso (< 1.5 km)†			Kachinjika (2.5–3 km)†			Chimpuza (4–6 km)†			Magola (> 6 km)†		
	dry	rainy	postharvest	dry	rainy	postharvest	dry	rainy	postharvest	dry	rainy	postharvest
Number of households	26	22	22	27	19	24	31	22	29	29	17	22
Collection distance (km)	2.0 (1.0–2.1)	1.5 (1.0–2.0)	2.0 (1.0–3.0)	4.0 (3.2–4.8)	3.0‡ (2.3–4.0)	3.0‡ (2.0–4.0)	4.0 (2.0–4.5)	3.0 (2.0–4.0)	2.0 (1.5–4.4)	1.0 (0.5–1.8)	1.5 (0.9–2.0)	1.0 (0.9–1.6)
Per capita wood (kg)	10.1 (6.1–13.5)	11.9 (6.0–17.6)	10.4 (8.2–14.9)	9.2 (5.9–12.3)	10.5 (6.0–17.8)	11.1 (7.6–17.4)	8.0 (3.7–12.5)	9.8 (7.6–14.4)	12.0‡ (8.0–16.,7)	9.8 (4.8–13.4)	10.5 (4.0–14.8)	9.4 (7.2–14.6)
Total collection time (hr)	6.0 (4.0–8.1)	4.0 (4.0–6.5)	6.8 (5.5–12.0)	12.0 (6.0–15.0)	8.0 (6.0–12.0)	8.0 (6.0–12.0)	6.0 (4.0–10.0)	8.0 (4.8–15.4)	8.0 (6.0–11.0)	4.5 (2.6–8.0)	4.0‡ (2.0–6.0)	4.0 (2.2–6.0)
Use of twigs (%)§	4	19	8	7	11	11	10	23	13	41	21	31

*Median (25th–75th percentiles).
†Between brackets: distance to woodlands.
‡Significantly different from dry season, $p < 0.01$.
§Percentage of households using twigs.

namely as regards collection distance and collection frequency.[6] These two variables were subsequently used for the categorization of households into four strategy groups, namely households with short collection distance and low collection frequency (referred to as *df*); long distance and low frequency (*Df*); short distance and high frequency (*dF*) and long distance and high frequency (*DF*). As the interest of this paper is in the differences between households within the same village but showing different responses, we chose a classification relative to village. In each village households were categorized above or below the median of the two respective variables for that village. This resulted in four strategy groups for each village. Results of a comparison of household characteristics and fuel supply and fuel use characteristics between the four strategy groups, differed little across villages and similar strategy groups from different villages were subsequently merged. The comparison between strategy groups that follows below is consequently independent of the earlier discussed differences between villages.

(a) *Collection time and amount of wood collected*

Households collecting at further distances, not surprisingly, spent more time on collection as travel time is increased (Table 5). Households collecting more frequently also showed an increased total collection time. Logically, households collecting at a greater distance and collecting frequently (*DF*) spent the most time (15 hours/week), whereas those staying nearby and collecting less often (*df*) spent "only" four hours a week. Most important, households collecting more often (*dF* and *DF*), gathered far greater amounts of wood (54 and 69 kg) than those collecting less frequent (*df* and *Df*: 32 kg).

(b) *Household characteristics*

Table 6 shows the household characteristics and fuel end uses of the four strategy groups. Households collecting more often (*dF* and *DF*) were generally larger in size and at the same time had more adult females who usually collect fuelwood. In addition, these households also had larger farms, especially *DF* households. There are two possible explanations. First, large households need larger farms for subsistence. Second, in Ntcheu District, more land usually means more plots at greater distances and, since women tend to combine fuel collection with field work, they are more likely to collect at further distances.

The larger amount of wood collected in the *dF* and *DF* strategy groups is needed to cover the greater fuel energy needs due to the larger household size. No differences existed in end-uses for the fuel between the strategy-groups (except for smoking fish: households collecting nearby tended to smoke fish more often). Still the larger household size as such is not the only reason for the greater fuelwood consumption. After correction for household size, the differences in amount of fuelwood collected per capita remained (Table 5). Smaller households tended to collect less wood, even per capita, and this indicates that these smaller households economize on fuelwood use. The reason for this probably lies in the fact that smaller households dispose of less labor and find it more difficult to collect fuelwood.

(c) *Involvement of household members, type of fuelwood used, storage and exchange of fuelwood*

Table 7 gives further information on fuel collection and fuel use in the four strategy groups. Logically, the number of persons involved in

Table 5. *Time spent on collection and total wood collected by fuel collection strategies, Ntcheu District, Malawi (n = 200)**

	Short distance low frequency *df* (72)	Long distance low frequency *Df* (60)	Short distance high frequency *dF* (44)	Long distance high frequency *DF* (24)
Total weekly collection time (hr)	4.0 (2.5–6.0)	6.0† (5.0–9.0)	9.5‡ (6.1–15.0)	15.0§ (12.0–20.0)
Total amount of wood collected (kg)	32.3 (22.4–41.2)	31.8 (23.4–42.8)	53.9‡ (43.8–75.0)	69.3‡ (52.7–90.7)
Wood collected per capita (kg)	8.2 (5.3–11.5)	7.7 (5.1–11.8)	10.5 (7.7–15.3)	11.8‡ (8.4–18.9)

*Median (25th–75th percentiles).
†Significantly different from *df*.
‡Significantly different from *Df* and *df*.
§Significantly different from *dF*, *df* and *DF*.

Table 6. *Socioeconomic characteristics and fuel end-uses by fuel collection strategies, Ntcheu District, Malawi (%, n = 200)*

	Short distance low frequency *df* (72)	Long distance low frequency *Df* (60)	Short distance high frequency *dF* (44)	Long distance high frequency *DF* (24)
Household size				
≤ 3	43	38	16	8
3–5	32	32	32	38
5–7	13	15	30	17
≥ 7	13	15	23	38
*Number of female adults**				
≤ 1	76	85	68	67
> 1	24	15	32	33
Size of farm (ha)				
≤ 0.5	14	7	7	8
0.5–1	46	52	46	25
1–1.5	17	18	27	38
> 1.5	24	23	21	29
End Use				
space heating	96	100	100	100
fish smoking	53	33	63	28
beer brewing	13	15	7	8

*Females aged 16–59.

Table 7. *Persons involved in fuelwood collection, type of fuel used and fuel end-uses of rural households by fuel collection strategy, Ntcheu District, Malawi (%, n = 200)*

	Short distance low frequency *df* (72)	Long distance low frequency *Df* (60)	Short distance high frequency *dF* (44)	Long distance high frequency *DF* (24)
Household members involved				
— No. persons collecting*	1.0 (1.0–1.0)	1.0 (1.0–1.0)	2.0† (1.0–2.0)	2.0† (1.0–3.0)
— Households enlisting young or old members	18	18	43	38
Type of fuel used				
— Households using twigs	15	12	27	8
— Households using wood of mango trees	58	60	61	58
Fuel end-use				
— Households having stock	31	30	34	46
— Households exchanging fuelwood	38	38	23	29

*Median (25th–27th percentiles).
†Significantly different from *df* and *DF*.

collection was larger among households collecting more frequently (*dF* and *DF*). As shown in Table 5, these households comprised more adult females and they share the collection of fuelwood. Furthermore, Table 7 shows that *dF* and *DF* households were more likely to involve younger members as well as elderly people in fuel collection (43 and 38% of the households respectively) compared to 18% in the other groups. The extra cost in terms of collection time is apparently spread among more household members.

In respect to type of fuel used there were no significant differences between the groups but there was a tendency for households collecting at a short distance (*df* and *dF*) to use more twigs. This same

trend also showed up in the earlier village analysis. No further differences were found as regards the use of mango cuttings, stock piling of fuelwood and exchanging of fuelwood for food.

6. DISCUSSION AND CONCLUSIONS

This paper describes and analyses the responses to a decreasing fuelwood availability among rural households in Ntcheu District, Malawi. Responses were examined, by first comparing fuel supply and use patterns in four villages located at different distances from woodlands. Second, households that use different collection strategies were compared with regard to collection distance and collection frequency to meet their energy needs.

The comparison of villages revealed that with increasing distance to woodlands households initially collected further away, spending more time on collection. But when distance to woodlands increased further, households returned to nearby places, using less time for collection. In addition, they switched to twigs, greater amounts of which must be collected because of their poor burning qualities. Therefore, results of our study indicate that distance to collection place and collection times as such are not reliable indicators of fuelwood shortages as is so often postulated in the literature (Hoskins, 1980; Howes, 1985; Schenk-Sandbergen, 1985; ETC, 1987b; Groen, 1988/89).

A short collection distance and reduced collection time does not necessarily represent a situation of surplus fuelwood availability. This point is made clear by the finding that households from the same village often show considerable differences in collection strategies. Household collection strategies differed particularly as regards collection distance and collection frequency. Within the same village some households may collect far away, others nearby and, likewise, some households collect frequently, others less often. Households that tend to collect further away and more frequently are large in size with more female adults. More household members partake in collecting fuelwood where more effort is needed and part of this extra effort is provided by the younger and the older household members. These larger households also collected more wood, even per capita, compared to smaller households. Although smaller households have fewer people and, presumably, need less wood than larger households, it is reported that per capita wood collection is usually larger in small households (Fleuret and Fleuret, 1978; Hosier, 1984). In this study, however, smaller households tended to collect less wood per capita compared to larger households. This indicates that in the present study population, smaller households do economize on fuelwood use.

Small households are either households comprising a young married couple possibly with small children, or households with an old couple whose children are married and have started their own household. Women in these households have little opportunity to share production and reproduction duties (Hayes, 1990; Kayongo-Male and Onyango, 1991). The ensuing time constraints will keep women from spending more time in fuelwood collection and they respond to a decreasing fuelwood availability by reducing the amount of wood collected and consumed. If this is true it means that households are more vulnerable in certain parts of the life cycle (Kayongo-Male and Onyango, 1991), and less at other times, for example during the middle domestic stages when households are larger and more labor is available.

The results of this study suggest that the amount of wood collected and, hence, consumed, is not only determined by fuelwood availability, but the more by labor availability. As noted by Dewees (1989), even in situations where fuel is available in abundance, level of fuel consumption can be quite low when there are constraints in household labor. Conversely, if labor is abundant, time spent on collection and the level of fuel consumption can be quite high.

Several authors refer to a strong seasonality in fuel collection and fuel use (Hosier, 1984; Howes, 1985). This study showed that especially in the village located at more than 6 km from woodlands, quite a number of households decide to stop collecting fuelwood during the rainy season. These households usually use wood from stocks they have built up during the dry season. The use of stocked wood is a way to save time in a period when agricultural field work demands a lot of women's time. Households that collect fuelwood throughout the year, however, show no major seasonal differences with respect to the amount of fuelwood collected per capita, collection time or distance.

The households in the present study were suffering fuelwood problems, although conditions in Malawi still compare favorably with other parts of Africa, such as the Sahel. Fuelwood is essentially still regarded a "free" good by the population and very little fuelwood is actually purchased. Although households had to go further away to collect it, the extra costs and sacrifices were not so high that people preferred to pay for the wood. For the same reason, the role of household income is not opportune in the present case. Nevertheless, it appears that under these conditions people start with increasing collection efforts, together with economizing in fuelwood use and a shift to lesser quality fuel. As households start to collect these fuels nearby their houses, the surrounding areas will be further depleted from wood, bringing the households in an even worse position in future.

Other studies within the same research project on the relationship between fuelwood availability and nutrition, revealed that a decrease in fuelwood use is

associated with a reduced food energy intake from cooked foods made of cereals, and from other food groups other than cereals, especially beans (Brouwer *et al.*, 1996a, 1996b). The reduction of intake from food groups other than cereals forms a point of special concern in view of the already overwhelming dependence on cereals in Malawi. A reduced use of fuel may lower the already marginal quality of the diet.

Data in this study refer to specific rural conditions in Malawi. The relatively small number of households involved allowed for only a limited disaggregation. More research is needed in other rural environments and in urban conditions as well in order to come to firm conclusions. But, the present results already give starting points for development efforts to reverse or prevent negative effects of a decreasing fuelwood availability. Most households in the research area collected wood within a distance of 4–5 km. Soussan (1988) already noted that the distance women can walk with a bundle of fuelwood is limited, up to 10 km in extreme circumstances. In consequence, large fuelwood plantations that have to supply whole regions are less suitable for village supply because they are situated at too large distances. Furthermore, populations are never homogeneous and, consequently, not all are affected in the same way. This study showed that especially smaller households are vulnerable in terms of amount of wood collected and, therefore, should receive careful attention in development efforts.

NOTES

1. For each individual member, the sources of fuelwood visited for collection were asked. For each source separately, the household member was asked to indicate frequency of collection, distance and amount of fuelwood collected.

2. Total weekly quantity of fuelwood collected and, likewise, total collection time, were calculated by summing total weekly amount collected and total collection time respectively for each individual household member. For each household member, total amount of fuelwood collected (or total collection time) was calculated by summing frequency of collection multiplied by amount of fuel collected (or by collection time) per trip.

3. Splitwood: logs and heavy branches of various tree species which are usually split with axes into smaller pieces to make them suitable for use in a three-stone fire. Branches: wood with a diameter of 2–5 cm. Twigs: all woody materials with diameters less than 2 cm.

4. MK = Malawi Kwacha. In 1990–91 minimum government wage was 40 MK/month. Average household income in research population was 25 KM/month. 1 MK ~ 0.4 US$ in 1990–91.

5. Aerial photographs dated from 1982 and were kindly made at our disposal by the Office of the President and Cabinet, Survey Department, Blantyre.

6. The relations between distance, time per collection trip, frequency and size of a bundle were examined with the help of PRINCALS, a nonlinear principal component analysis (Gifi, 1985) to reduce the number of variables. Analysis revealed two dimensions, explaining 46% and 30% of the variance respectively (eigen value > 0.2). The first dimension was related to distance to collection place and, hence, to trip time and the second dimension represented frequency of collection. Size of bundle was related to both dimensions. Component loadings are shown in Table A1.

REFERENCES

Ardayfio, E., *The Rural Energy Crisis in Ghana: Its Implications for Women's Work and Household Survival* (Geneva: International Labour Office, 1986).

Armitage, J. and G. Schramm, *Managing the Supply and Demand for Fuelwood in Africa* (London: The Johns Hopkins University Press, 1989).

Bradley, P. N., "Survey of woody biomass on farms in Western Kenya," *Ambio*, Vol. 17, No. 1 (1988), pp. 40–48.

Bradley, P. N., *Woodfuel, Women and Woodlots* (London: Macmillan, 1991).

Brouwer, I. D., L. M. Nederveen, A. P. den Hartog and A. H. C. Vlasveld, "Nutritional impacts of an increasing fuelwood shortage in rural households in developing countries," *Progress in Food and Nutrition Science*, Vol. 13 (1989), pp. 349–361.

Brouwer, I. D., A. P. den Hartog, M. O. K. Kamwendo and M. W. O. Heldens, "Wood quality and wood preferences in relation to food preparation and diet composition in Central Malawi," *Ecology of Food and Nutrition*, Vol. 35 (1996a), pp. 1–13.

Brouwer, I. D., T. M. A. Wijnhoven, J. Burema and J. C. Hoorweg, "Household fuel use and food consumption: Relationship and seasonal effects in Central Malawi," *Ecology of Food and Nutrition* (1996b).

Cecelski, E., *The Rural Energy Crisis, Women's Work and Basic Needs: Perspectives and Approaches to Action* (Geneva: International Labour Office, 1985).

Cecelski, E., *Energy and Rural Women: Crisis, Response and Policy Alternatives* (Geneva: International Labour Office, 1987).

Cline-Cole, R. A., H. A. C. Main and J. E. Nichol, "On fuelwood consumption, population dynamics and deforestation in Africa," *World Development*, Vol. 18, No. 4 (1990), pp. 513–527.

Corbett, J., "Famine and household coping strategies," *World Development*, Vol. 16, No. 9 (1988), pp. 1099–1112.

Dankelman, I. and J. Davidson, *Women and Environment in the Third World* (London: Earthscan, 1989).

Dewees, P. A., "The woodfuel crisis reconsidered: Observations on the dynamics of abundance and scarcity," *World Development*, Vol. 17, No. 8 (1989), pp. 1159–1172.

Eckholm, E., G. Foley, G. Bernard and L. Timberlake, *Firewood, The Crisis that Won't Go Away* (London: Earthscan and IIED, 1984).

ETC, *Wood Energy Development: Biomass Assessment. A Study of the SADCC Region* (Leusden: ETC, 1987a).

ETC, *Wood Energy Development: Policy Issues. A Study of the SADCC Region* (Leusden: ETC, 1987b).

Foeken, D. and J. Hoorweg, *Seasonality in the Coastal Lowlands in Kenya. Part 2: Introduction to Seasonality* (Nairobi: Ministry of Planning and National Development, and Leiden: African Studies Centre, 1988).

Food and Agriculture Organization (FAO), *Rural Women, Forest Outputs and Forestry Projects* (Rome: FAO, 1983).

Food and Agriculture Organization (FAO), "The impact of fuelwood scarcity on dietary patterns: Hypotheses for research," *Unasylva*, Vol. 41, No. 160 (1990/1991), pp. 29–34.

Fleuret, P. C. and A. K. Fleuret, "Fuelwood use in a peasant community: A Tanzanian case study," *Journal for Developing Areas*, Vol. 12 (1978), pp. 315–322.

French, D., "Confronting an unsolvable problem: Deforestation in Malawi," *World Development*, Vol. 14, No. 4 (1986), pp. 531–540.

Gifi, A., *Princals* (Leiden: Department of Data Theory, University of Leiden, 1985).

Groen, B., "Women and woodfuel: An overview, *Netherlands Review of Development Studies*, Vol. 2 (1988/1989), pp. 35–51.

Hayes, J. J., "Not enough wood for the women: How modernization limits access to resources in the domestic economy of rural Kenya" (Ann Arbor, MI: UMI Dissertation Information Service, 1990).

Hosier, R., "Domestic energy consumption in rural Kenya: Results of a nationwide survey," in C. Barnes, J. Ensminger and P. O'Keefe (Eds.), *Wood, Energy and Households: Perspectives on Rural Kenya* (Stockholm: The Beijer Institute, 1984).

Hoskins, M. W., "Community forestry depends on women," *Unasylva*, Vol. 32, No. 130 (1980), pp. 27–32.

Howes, M., "Rural energy surveys in the Third World. A critical review of issues and methods," IDRC Manuscript Report 107e (Ottawa: International Development Research Centre, 1985).

Kayongo-Male, D. and P. Onyango, *The Sociology of the African Family* (New York: Longman Inc., 1991).

Ki-Zerbo, J., "Women and the energy crisis in the Sahel," *Unasylva*, Vol. 33 (1981), pp. 5–10.

Longhurst, R., "Cropping systems and household food security: Evidence from three West African countries," *Food and Nutrition*, Vol. 11, No. 2 (1985), pp. 10–16.

Longhurst, R., "Household food strategies in response to seasonality and famine," *IDS Bulletin*, Vol. 17, No. 3 (1986), pp. 27–35.

Malawi Government, *Malawi Rural Energy Survey* (Lilongwe: Energy Studies Unit, 1981).

Malawi Government, *Statement of Development Policies 1987–1996*, (Lilongwe: Office of the President and Cabinet, Department of Economic Planning and Development, 1987a).

Malawi Government, *Malawi Population and Housing Census 1987. Vol. 1: Summary of Final Results* (Zomba: National Statistical Office, 1987b).

Malawi Government, *Malawi Statistical Yearbook 1987* (Zomba: National Statistical Office, 1989).

Mung'ala, P. M. and K. Openshaw, "Estimation of present and future demand for woodfuel in the Machakos District," in C. Barnes, J. Ensminger and P. O'Keefe (Eds.), *Wood, Energy and Households: Perspectives on Rural Kenya* (Stockholm: The Beijer Institute, 1984).

Ngugi, A. W. and P. N. Bradley, *Agroforestry, Soil Conservation and Woodfuel in Murang'a District* (Nairobi: The Beijer Institute, 1986).

Norusis, M. J., *SPSS Statistical Data Analysis* (Chicago: Statistical Package for Social Sciences Inc., 1990).

Schenk-Sandbergen, L., *Poor Women and New Water and Fire Technology in Gujarat (India)* (Amsterdam: University of Amsterdam, 1985).

Shanahan, Y., "Woodfuel and the rural household," *The Courier*, Vol. 95 (1986), pp. 70–72.

Siegel, S. and N. J. Castellan, *Nonparametric Statistics for the Behavioral Sciences* (New York: McGraw-Hill Book Company, 1988).

Soussan, J., *Primary Resources and Energy in the Third World* (London: Routledge, 1988).

Wilkinson, L., *SYSTAT: The System for Statistics* (Evanston, IL: SYSTAT Inc., 1989).

APPENDIX

Table A1. *Relations between distance, time per collection trip, frequency and size of bundle: Component loadings*

	Distance	Trip time	Frequency	Size of bundle
Dimension 1	0.90	0.90	–0.21	0.42
Dimension 2	0.22	0.27	0.80	–0.65